Spider Web shaped Near-field UHF RFID Reader Antenna for Healthcare and IoT Applications

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***Abstract*— This paper presents a spider web-shaped antenna for near-field UHF RFID applications. The proposed design consists of concentric decagons, and open-ended microstrip lines etched on the circular substrate. The proposed design features a uniform and fairly strong electric field distribution in the nearfield region. In addition, this antenna exhibits impedance matching ranging from 902 MHz – 925 MHz and further poses low gain characteristics, that is required for most of the nearfield application in order to avoid misreading of other tags. Moreover, this design provides symmetric current distribution throughout the structure, thereby solves orientation sensitivity problems of low-cost linearly polarised tag antennas. The measurement results demonstrate tag can successfully read expensive jewellery items, tagged pills and tag placed in different orientations. Therefore, the proposed reader antenna is a good candidate for near field RFID, healthcare and IoT Applications.**

Keywords—Radio frequency identification(RFID); Near-field antenna; item-level tagging

I. Introduction

Radiofrequency identification (RFID) is forecasting innovative applications in combination with the Internet of things (IoT). The RFID technology is considered as a last-mile solution for IoT devices, especially UHF RFID systems are more promising due to their long read range, multiple tags reading, simple printable tag structures and fast reading capabilities [1]. The UHF RFID systems have already proved its importance in retail, supply chain management, healthcare, security and logistics applications. The nearfield RFID tag-based systems are more suitable for item-level tagging and environment-sensitive applications. However, one of the key technical problems in the UHF band near-field RFID reader antenna design is to generate a sufficiently strong and relatively uniform field distribution. Also, there are some additional requirements for expensive goods and healthcare-related applications such 100 % successful reading of tagged items and avoidance of miss reading of other tags nearby. Moreover, low-cost commercially available tag antennas are linearly polarised and prone to orientation sensitivity problems. Therefore, a reader antenna is required, which can successfully read tags placed in any orientation with uniform electric and magnetic field characteristics [2]. A mender line microstrip based reader antenna with dimensions 140×100×2 mm^3 has been proposed in [3]. However, this antenna exhibited strong electric field distribution in a small area above the antenna. Another meander line antenna proposed in [4] achieved uniform electric and magnetic field distributions, but with large dimensions 480×200×1 mm^3.

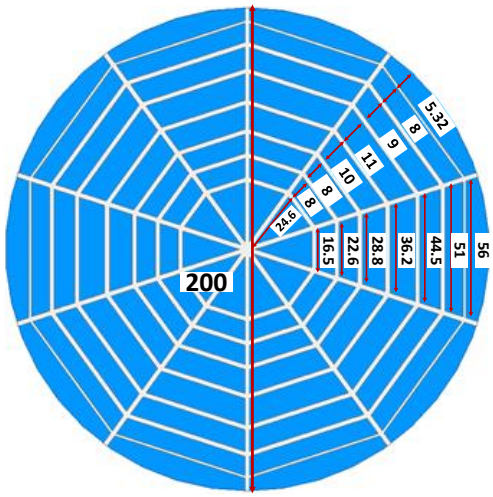


Fig. 1 Geometry and structure of proposed UHF RFID Near field reader Antenna with detailed dimensions (all dimensions are in mm)

II. Antenna Configuration

Fig. 1 shows the configuration and detailed dimensions of the proposed RFID reader antenna. The proposed design consists of the integration of seven concentric decagons and five open-ended microstrip lines etched on a circular FR4 substrate (ε_r = 4.4, tan σ = 0.02) with radius = 100 mm and thickness of 1 mm. The antenna is fed at the centre point and backed by a ground plane. The antenna is designed and optimised using CST Microwave studio. The width of the copper trace for all decagon and microstrip lines is 2 mm.

III. Results and Discussion

Fig. 2 shows the measured and simulated S11 parameter of the near-field reader antenna. This antenna exhibits impedance

match and corresponding bandwidth ranging from 902 – 925 MHz. There is a lit bit shift in the measured S11 parameter, which may be caused due to the difference in the simulated and actual values of relative permittivity and loss tangent of the substrate. The simulated surface current distribution of proposed reader antenna at 915 MHz is illustrated in Fig. 3 (a) that shows the symmetric current distribution in the whole antenna structure. Thereby solves orientation sensitivity problems of low-cost linearly polarised tag antennas. Fig. 3 (b) depicts the simulated electric field distribution of proposed antenna at 915 MHz in the horizontal plane above the antenna at 5, 10, 15 and 20 mm. As can be seen from figure 3 (b), this antenna poses a uniform and strong electric field distribution in the near-field region.

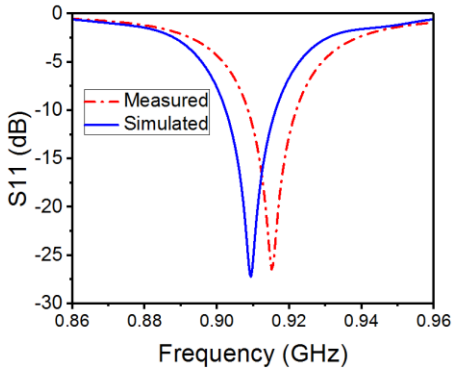
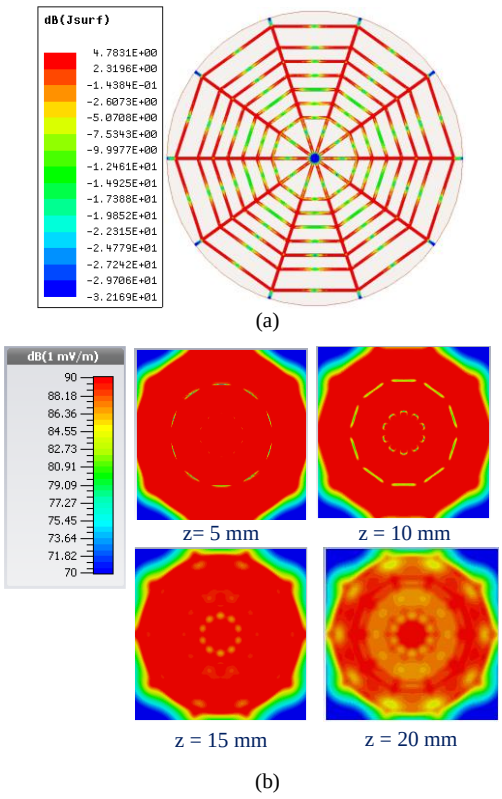


Fig. 2 Measured and simulated S11 parameter of the proposed near-field reader antenna



(a)

(b)

Fig. 3 (a) surface current distribution of proposed near-field reader Antenna at 915 MHz (b) Electric field distribution of the proposed antenna at 915 MHz (in the horizontal plane above antenna at different height)

Moreover, the uniform electric field distribution (ED-field) covers almost all area above the antenna equivalent to antenna dimensions (200×200 mm^2). As mentioned [3], the reader antenna can read all tag simultaneous with electric field distribution of more than 85 dB (1mV/m). Therefore, the ED-field range was fixed from 70 dB to 90 dB. To validate it further, a prototype of the antenna was fabricated and tested using different tag reading scenarios to prove the concept. The fabricated antenna was attached to Impinj reader setup with 30 dBm output power as shown in Fig. 4 (right inset). The antenna was used to read tagged pills placed above the antenna in different orientations on 10 mm foam as depicted in left inset of Fig. 4. Similarly, the antenna is tested for reading tags placed in different orientations 10 mm above the antenna. Furthermore, the performance of this antenna is corroborated by placing tagged jewellery items placed on cardboard boxes wrapped in silk cloths. The experimental results shows 100 % reading of tags above the antenna surface up to 20 mm above antenna and further does not read any tags outside the antenna surface to avoid misreading of nearby tags.

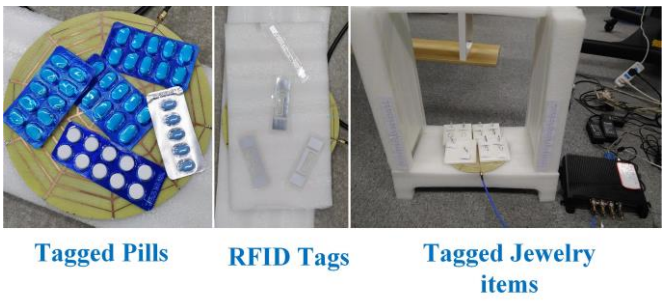


Fig. 4 Reading experiment of tagged pills, RFID tags, and jewelry items placed in different orientations using fabricated prototype of reader antenna

IV. Conclusion

In this paper, a spider web-shaped near field reader antenna was proposed with uniform electric field characteristics. The proposed antenna featured impedance matching ranging from 902 MHz – 925 MHz and low gain characteristics. The experiment result demonstrates the performance of reader antenna in terms of 100 % reading of expensive goods such as jewellery items and medical pills, and further avoids the false reading of expensive jewellery item/medical pills devised by the doctor on prescription. Therefore, this antenna is suitable for item-level reading in healthcare and IoT applications.

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